

5.0 TRACKING PROCEDURES FOR DIRECTIONAL ANTENNAS USED TO ACQUIRE DATA FROM REAL-TIME TRANSMISSIONS SYSTEM SENSORS

All operators of satellite stations designed to receive any type of direct readout transmission from polar orbiting satellites need to know the satellite's position in time and space in order to know when to operate their equipment and to permit them to geographically locate the received data. Operators of stations using directional antennas also need this information to determine antenna pointing angles, although this is not required of stations using fixed, omnidirectional antennas.

One of the primary sources of information concerning a satellite's position in time and space is the TBUS predict bulletin. These bulletins are issued daily for all NOAA satellites, both polar orbiting and geostationary. The information in the bulletin can be used in a variety of computer programs (or hand plotted, using graphical techniques) to determine the antenna azimuth and elevation angles necessary to follow a polar orbiting satellite passing within receiving range of a given station. In advanced satellite receiving systems, the output can provide commands to directly drive the antenna aiming hardware. The content and primary sources of the TBUS bulletin are described in Sections 5.1 and 5.2. Alternate sources and forms of satellite prediction information are identified in Section 5.2.

The code form of the TBUS bulletin, an example of an actual bulletin, and a decoding exercise are given in Appendix A.

5.1 TBUS BULLETIN

The TBUS bulletin contains information on satellite equator crossing times and longitudes, orbit numbers, orbital period, longitudinal time, and longitudinal increments between successive orbits; also, satellite positions at two-minute intervals (for a reference orbit), transmission frequencies, and other information related to satellite tracking and performance. The orbital information is valid for the third day **after** the date on which the bulletin is prepared and transmitted.

The bulletins are prepared by NESDIS and transmitted through the National Weather Service Telecommunications Gateway (KWBC) to major meteorological centers and relay points around the world, which comprise the Global Telecommunications Service (GTS). The GTS primarily serves the international meteorological community. However, the TBUS bulletin receives further distribution via the Internet, electronic mail, high frequency radio broadcasts and commercial data services.

There are two forms of the TBUS bulletin. One form, identified as TBUS-1, is used to convey information about satellites that are descending in daylight (traveling north-to-south on the sunlit portion of the orbit). The second form, TBUS-2, provides data for satellites that are ascending in daylight (northbound on the sunlit portion of the orbit).

A schematic representation of the TBUS-1 and TBUS-2 bulletins is shown in Figure 5.1-1.

Both bulletins consist of four parts. Part 1 is quite short. It identifies a reference orbit on a given day (three days after the date of the bulletin) and gives the equator crossing time and longitude for this reference orbit. This is followed by an orbital nodal period and a longitudinal increment—the separation between successive equator crossings, measured in degrees. The orbit number of the fourth and eighth orbits following the reference orbit are then listed along with the equator crossing times and longitude of these orbits.

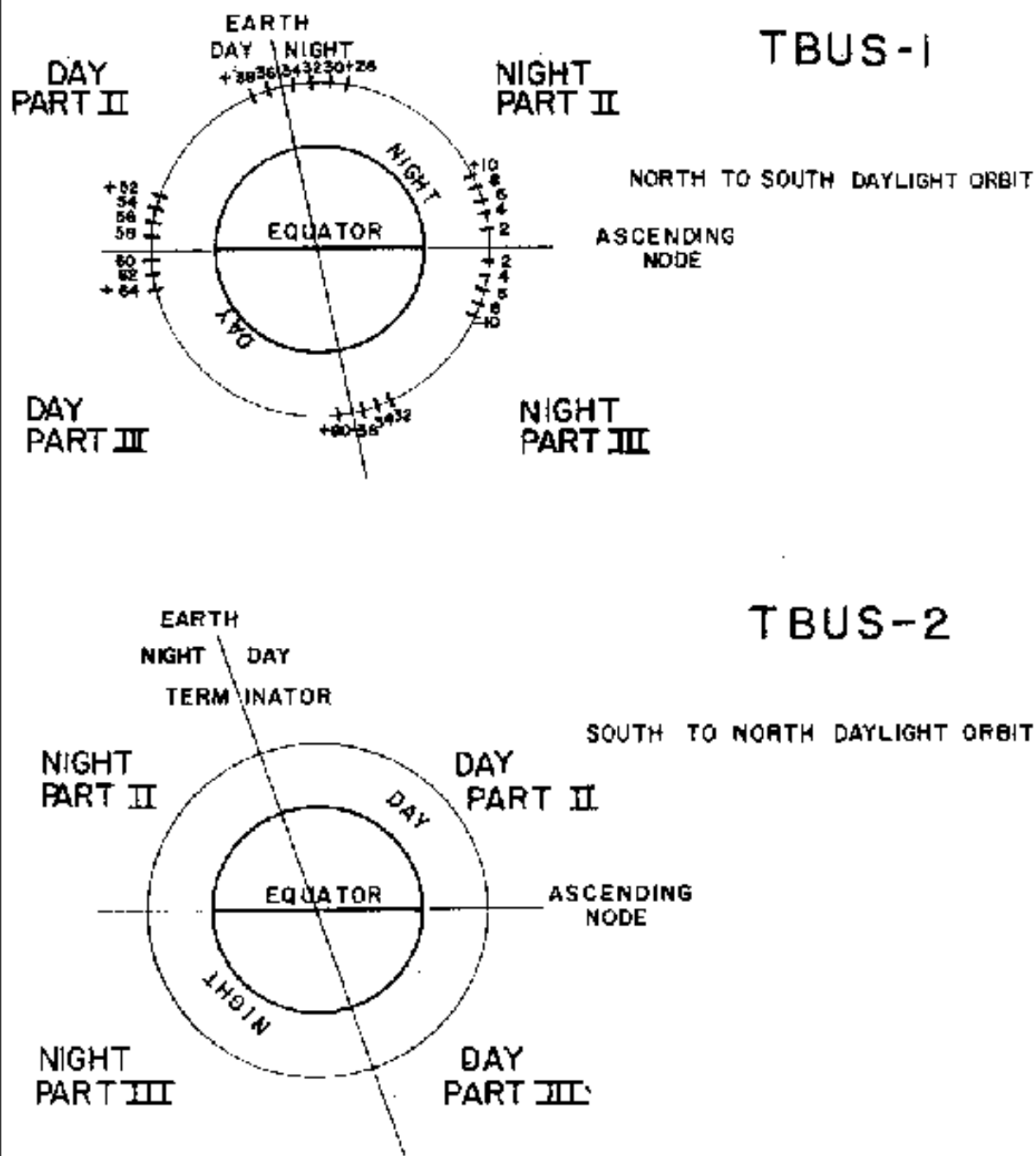
By itself, Part 1 contains sufficient information to permit the user to calculate future equator crossing times and longitudes several days in advance with considerable accuracy. During periods of maximum solar activity, however, the accuracy extrapolated from Part 1 information diminishes if the extrapolations are carried much more than a week ahead.

Parts II and III of the bulletins are quite lengthy. Part II (Day) contains predicted subpoint and height data at two-minute intervals for the portion of the orbit that is sunlit north of the equator. Part III (Day) contains predicted subpoint and height data at two-minute intervals for the portion of the orbit in darkness north of the equator. Part III (night) contains predicted subpoint and height data at two-minute intervals for the portion of the orbit in darkness south of the equator. All times are referenced to the ascending node (northbound equator crossing) and are given as minutes after or before this time (refer to Figure 5.1-1).

Part IV is relatively short, and usually consists of four items: a code group, transmission frequencies of each operating direct readout sensor system, the on-board clock variations and remarks. The code group consists of orbital parameters used to generate parts I through III. It is intended for use by those station operators needing more precision in satellite tracking and having appropriate computer programs to ingest such data and produce both equator crossings and antenna pointing angles.

The remarks in Part IV are in plain language and advise of problems or changes in the mode of operating the satellite, including the AVHRR/3 channels selected for the APT transmissions. Direct readout transmission frequencies are discussed elsewhere; in summary, the APT service for NOAA KLM will utilize 137.50 or 137.62 MHz; the HRPT will transmit on 1698.0 or 1707.0 MHz (1702.5 MHz is available for standby); the DSB beacon will operate on 137.35 or 137.77 MHz.

Figure 5.1-1. Schematic representation of TBUS-1/TBUS-2 information.



5.2 ALTERNATE SOURCES AND FORMS OF SATELLITE PREDICTION POSITION INFORMATION

The primary source for orbital prediction information for NOAA operated satellites is directly from NOAA via the Global Telecommunications System (GTS) or the Internet, and the main form of this information is the TBUS bulletin. Many HRPT and APT station operators, and some government agencies, do not have access to the GTS or Internet and must be able to obtain orbital prediction information from other sources.

These alternate sources include, but are not limited to, WEFAX broadcasts from U.S. geostationary satellites, electronic mail, telephone bulletin board systems, high frequency radio broadcasts, commercial environmental data providers, and the Aeronautical Fixed Telecommunications Network (AFTN).

NOAA maintains an Internet site (the NOAASIS) that always has the current TBUS bulletins. The TBUS bulletin is also broadcast once daily as part of the WEFAX transmission from U.S. geostationary satellites, for stations within range and with the proper receiving equipment.

With the proper receiving equipment and teleprinter, some station operators are able to intercept the GTS radio-teletype (RTTY) meteorological transmissions containing the TBUS message. A number of major communications centers on the GTS relay this information via radio-teletype, especially for the use of ships on the high seas. Potential users would have to contact the nearest major center for frequencies and schedules.

In Africa and parts of the Middle East, a number of government meteorological services receive the TBUS bulletin as part of the Meteorological Data Distribution (MDD) broadcast via the METEOSAT geostationary satellite. Satellite readout station operators without other sources of orbital information are urged to contact an office of their national meteorological service to see if arrangements can be made to obtain copies of these messages.

The nonprofit, Radio Amateur Satellite Corporation (AMSAT) and its affiliates around the world serving the amateur radio community, broadcast the two line element messages daily via packet radio teletype. These broadcasts can be received in many parts of the world.

As of mid-1995, the U.S. Coast Guard included the TBUS message in high frequency, radio teletype broadcasts directed at the eastern and central North Pacific Ocean.

A more complete list of satellite navigation sources and points of contact is included in Appendix E.

Apart from the TBUS messages, the other most common form for transmitting orbital information are the two-line element (TLE) messages. These have the advantage of being very compact, and can be incorporated into many computer programs which will produce accurate

satellite tracking and gridding information. The two-line, mean Keplerian orbital elements are derived from the NORAD SGP4 (Simplified General Perturbation) model. While similarly named elements appear in both the two-line and TBUS messages, the values are not interchangeable between systems to compute satellite tracks using the TBUS or NORAD two-line elements. Doing so will result in large errors. Details on decoding the two-line element messages appear in Appendix A.

5.2.1 SOURCES OF ORBITAL INFORMATION FOR NOAA POLAR ORBITING SATELLITES

5.2.1.1 Internet

NOAASIS World Wide Web site

Operated by NOAA/NESDIS has orbital elements (TBUS, two-line) for all NOAA satellites, operating schedules, technical information and documents.

URL: <http://noaasis.noaa.gov/NOAASIS/>

For further information, contact NESDIS via email at satinfo@noaa.gov or

fax: 301-457-5620

telephone: 301-457-5681 x126

mail:

Direct Readout Services Coordinator
NOAA/NESDIS E/SP3
FOB4, Room 3320
5200 Auth Road
Suitland, MD 20746-4304
USA

Celestial World Wide Web site

Operated by T. S. Kelso and has two-line elements only for all NOAA satellites, and many other satellites.

URL: <http://www.celestrak.com>

Florida State University

Provides the current TBUS only, in directory /pub/weather/satellite/.

URL: <ftp://ftp.met.fsu.edu>

"WXSAT" email listserver

This is a privately run service that will email orbital elements, satellite schedules, and other items of interest, without charge. To subscribe and receive additional information, send an email to: wxsat-request@met.fsu.edu. The email should contain no "subject" line, and the text of the message should read: "subscribe (enter your name)."

5.2.1.2 Telephone Bulletin Board Systems (BBS)

Dial-in telephone Bulletin Board Systems (BBS) have been replaced with the increasingly widespread use of the Internet. If any direct readout users or Bulletin Board System operators are aware of such telephone dial-in systems distributing meteorological satellite orbital elements, please advise satinfo@noaa.gov with complete information.

5.2.1.3 Amateur Radio Transmissions

For more information on these broadcasts of satellite prediction messages, available in much of the world via the Radio Amateur Satellite Corp., contact:

AMSAT-NA
850 Sligo Avenue, Suite 600
Silver Spring, MD 20910 USA

5.2.1.4 Commercial On-Line Services

Orbital elements are available in the Space Forum of the Compuserve Information Service, the Astronomy Forum of America On Line. Further information about any of these service providers is available from:

America On Line
8619 Westwood Center Drive
Vienna, VA 22182 USA

Compuserve Information Service
5000 Arlington Centre Blvd
Columbus, OH 43220 USA

Additions and corrections to this list of sources for satellite orbital elements should be mailed to:

Direct Readout Services Coordinator,
NESDIS Direct Services Division E/SP3,
FOB4, Room 3320

5200 Auth Road
Suitland, MD 20746-4304
USA

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